BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B07 08017

SUBJECT: LRV Weight Status Reporting
Case 320

DATE: August 11, 1970

FROM: J. C. Slaybaugh

ABSTRACT

Current methods of reporting Lunar Roving Vehicle (LRV) weight status have led to some confusion. This is due, in part, to the fluid nature of the data being reported, but is also largely a result of the different systems of weight accounting employed by MSC and MSFC. Although these systems produce minor inconsistencies in the actual weights reported, the discrepancies reflect a more basic problem of lack of common intercenter definitions and reporting format.

This memorandum presents the status of the LRV weight as reported by MSC and MSFC during June and July, 1970, including a brief analysis of the major differences as reported. In addition, a set of candidate definitions and reporting format are presented to provide a basis for possible redefinition of reporting responsibility for the vehicle and its associated hardware. The revised definitions provide for a cleaner intercenter interface by having each Center account for the hardware it supplies. Previously some hardware supplied by one Center was reported by the other, leading to the current disorder in the LRV weight status. Continued confusion in this area can only lead to further problems in an already tightly scheduled program.

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MEMORANDUM FOR FILE

INTRODUCTION

Current methods of reporting Lunar Roving Vehicle (LRV) weight status have led to some confusion. This is due in part to the constant flux of the data being reported. It is also, however, largely a result of the different systems for weight accounting employed at MSC and MSFC. Although these systems produce minor differences in the actual values reported, the discrepancies reflect a more basic problem of lack of common definitions and reporting format between the Centers. Continued confusion in this area can only lead to further problems for an already tightly scheduled program.

This memorandum presents the current status of the LRV weight as reported by MSC and MSFC during June and July, 1970. In addition, a candidate set of LRV definitions and common format for weight accounting is presented in an attempt to provide a focus for possible future modifications.

As used herein, MSFC weights will refer to the weights reported by The Boeing Company (Huntsville) in its LRV Weight Status Reports. MSC weights refer to the LRV section of the Apollo Spacecraft Weight Status Summary reported by ASPO.

CURRENT STATUS

Figure 1, presents the most recent matching * set of LRV weight reports compiled by MSC and MSFC, along with the nominal vehicle weights as derived from the Apollo Program Specification, Revision B. The lowest portion of the "Current" bar is expanded in Figure 2, with a LM reference added.

Examination of these figures turns up several discrepancies in the weights reported by the Centers. Among these are:

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* MSC LRV data is based upon the Boeing Weight Status Report and therefore generally lags the latter by two weeks. The numbers used in the current discussion come from the June 12, 1970 Boeing Report and the July 1, 1970 MSC Weight Status Summary.

1. MSFC reports the "LRV Folded in LM Quad I" to be 460.9 lbs while MSC reports the same category as 457.8 lbs.

2. MSFC reports the Space Support Equipment (SSE) to be 26.80 lbs while MSC reports SSE as 22.7 lbs.

3. MSFC reports the Grumman (GAC) supplied hardware as 4.70 lbs, while MSC carries this weight as 3.1 lbs.

Although small in numerical value, as discussed above, these inconsistencies reflect a more basic problem in intercenter communication.

All three of these discrepancies are attributable to the SSE hardware interface and its definition by the Centers. MSC reports a 3.1 lb lighter "folded" vehicle than MSFC because the former includes GAC-furnished SSE as part of the LM structure. Similarly, in reporting SSE weight, Houston has reduced the Marshall figure by 3.1 lbs, and has subtracted one further pound to account for 0.95 lbs of SSE which MSFC reports as remaining on the LRV after deployment. Figure 2, therefore, shows an MSC SSE of 22.7 lbs as opposed to MSFC's 26.8 lbs. Finally, MSC carries the GAC-furnished hardware as 3.1 lbs, while MSFC reports that weight as 4.7 lbs.

In addition to the intercenter problems, however, several inconsistencies exist within the MSFC report. Figures 3-5 are reproductions of three pages of the June 12th report showing the following discrepancies:

1. The chassis subsystem weight reported for the "LRV folded in LM Quad I" (Figure 3) is 72.53 lbs, while the chassis subsystem listed under "LRV Deployed" (Figure 4) is only 70.22 lbs. The 2.31 lbs difference is attributed to chassis parts discarded after deployment, and is shown as part of the cross-hatched area in Figure 2.

2. The thermal protection subsystem as listed under the "LRV Folded in LM Quad I" weighs 15.7 lbs but an additional 0.60 lbs is listed under SSE thermal protection. The "LRV Weight Status Sheet" (Figure 5), however, lists the thermal protection subsystem as 16.3 lbs, with no SSE thermal protection weight.

Again, the numbers involved are not large, but the basic problem is one of applying consistent definitions to allow comparison of numbers provided from different sources.

Figure 6 presents the most recent MSFC LRV weight breakdown (July 15, 1970) compared to the previous month's figures, along with the reason for change of each subsystem.

CANDIDATE DEFINITIONS

As may be seen from the discrepancies discussed above there is a need for a consistent set of weight reporting definitions to be used throughout the program. The following candidate definitions have been developed in an effort to provide such a set. The first four definitions are the basic system components, which are then used to define the other elements. Figure 8 is a graphical representation of this breakdown.

VEHICLE: The Lunar Roving Vehicle as deployed on the lunar surface without the VEHICLE PAYLOAD:

- including any payload attachment hardware integral to the VEHICLE
- including any Space Support Equipment (SSE) integral to the VEHICLE
- excluding any payload attachment hardware attached to the payload and stowed separately on the LM
- excluding any SSE attached to the LM or removed from the VEHICLE after deployment.

SPACE SUPPORT EQUIPMENT (SSE): The equipment required to secure the VEHICLE to the LM during launch and flight to the moon, and the equipment required to deploy the VEHICLE from the LM to the lunar surface:

- excluding any equipment which is an integral part of the VEHICLE
- excluding any equipment which is supplied as part of the LM.

CREW SYSTEMS: The crew and all crew support systems carried on the VEHICLE.

CARGO: Samples and scientific, photographic and support equipment carried on the VEHICLE:

- including such payload attachment hardware as pallets, clips and rings which are installed on the VEHICLE on the lunar surface.

VEHICLE PAYLOAD: The CREW SYSTEMS and CARGO.

LRV IN LM: The VEHICLE and SSE.

LRV ON LUNAR SURFACE: The VEHICLE, CARGO and CREW SYSTEMS.

CONTROL WEIGHT: Weight established by the Program Director as the maximum allowable for a given Lunar Roving Vehicle configuration.

As defined above, the current reporting system, shown in Figure 1, has been modified in two ways. First, the VEHICLE has been defined to include all payload attachment hardware which is integrally part of the LRV. This change is depicted by the upward movement of the "Charged to" line from within the VEHICLE in Figure 1 to the VEHICLE/CARGO interface in Figure 7. The second change is the elimination of the GAC SSE from the vehicle reporting system (as is currently done by MSC). This change is shown by the elimination of the MSC supplied hardware from the bottom of Figure 7.

The revised definitions provide for a cleaner inter-Center interface by having each Center responsible for reporting the hardware it supplies. Previously (Figure 1) some hardware supplied by MSC (e.g., GAC SSE) was reported by MSFC, and vice versa.

CANDIDATE REPORTING FORMAT

Figure 8 presents a candidate format for reporting the weights defined above. The checks and crosses in each box represent values to be reported regularly to Headquarters for management purposes. The numbers in parenthesis are values which might have appeared in each box at the time of the 1 July MSC weight status report. It will be noted that the CARGO and CREW SYSTEMS are not reported as folded in LM Quad I, since they will be transported to the lunar surface in a separate stowage area. Similarly, the SSE is not reported under the operational LRV column since it is not part of the VEHICLE once it is deployed. Control weights are reported next to actual weights to provide a basis for comparison.

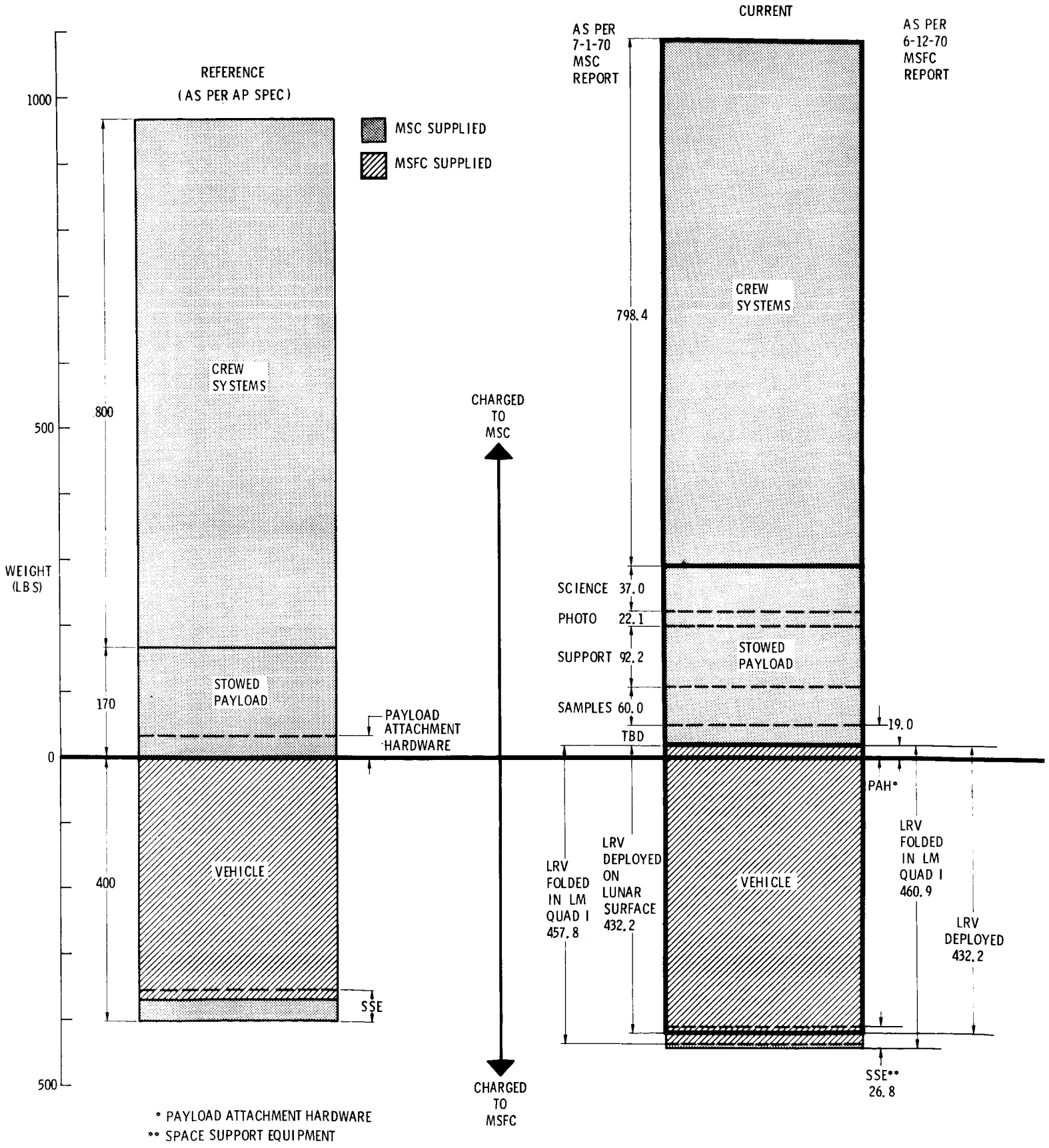
CONCLUSIONS

It is felt that the current status of LRV weight reporting has led to sufficient confusion to warrant a new set of definitions and reporting format. The set presented herein is one candidate for such data, designed to improve overall understanding of the LRV weight problem.

2032-JCS-meh

J. C. Slaybaugh

LUNAR ROVING VEHICLE
WEIGHT STATUS



* PAYLOAD ATTACHMENT HARDWARE
** SPACE SUPPORT EQUIPMENT

FIGURE 1

PRE-DEPLOYMENT
SSE INTERFACE

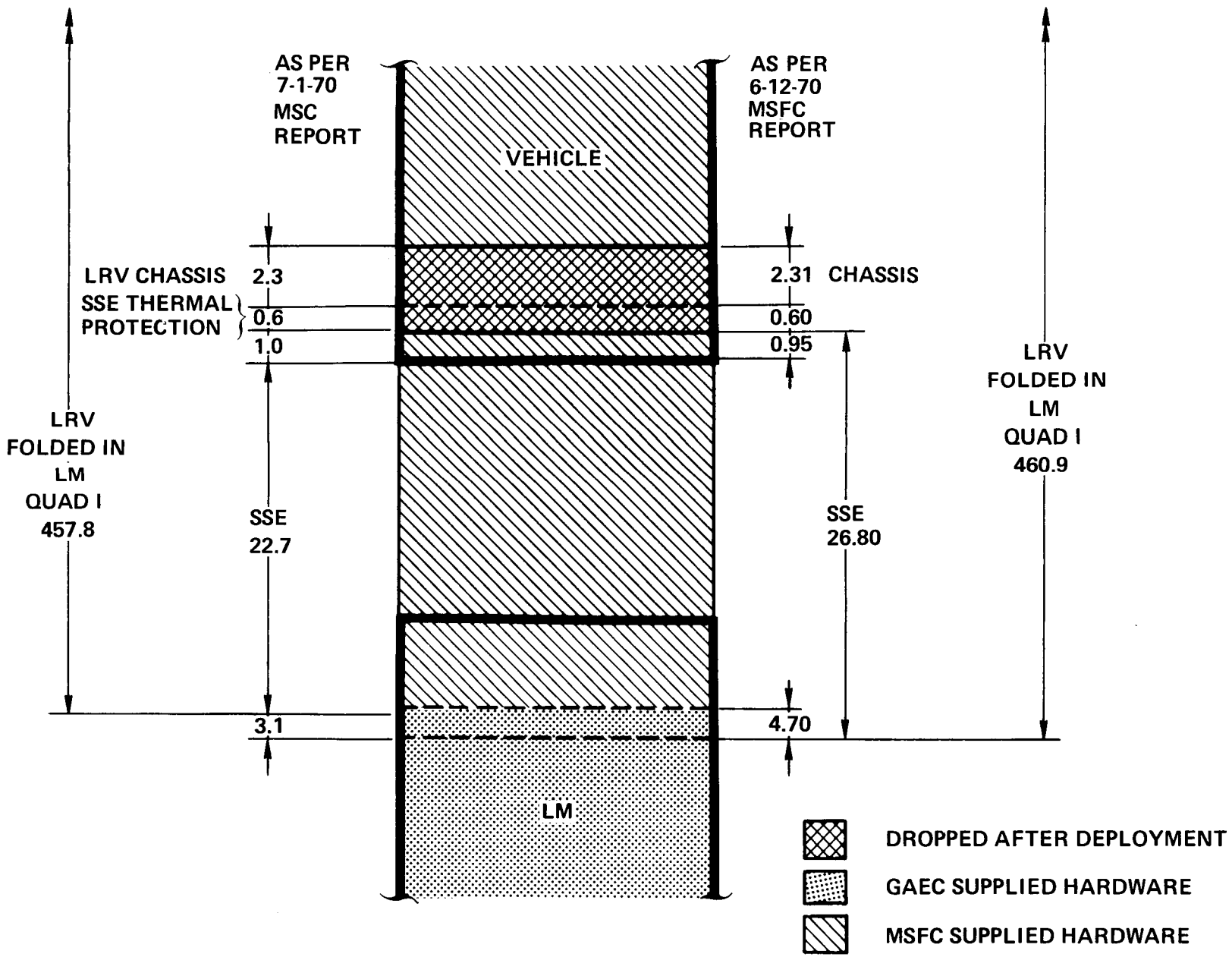


FIGURE 2

JUNE 12, 1970

LRV MASS PROPERTIES

LRV FOLDED IN LM QUADRANT I

ITEM	TOTAL WEIGHT	CENTERS OF GRAVITY			MASS MOMENTS OF INERTIA		
		X Inches	Y Inches	Z Inches	I_x(lb-in^2)	I_y(lb-in^2)	I_z(lb-in^2)
CHASSIS	72.53	75.23	0.00	103.51	19,649	50,407	68,514
SUSPENSION	19.64	70.50	0.00	114.41	7,636	3,630	10,612
STEERING	9.40	70.50	0.00	109.61	956	4,112	5,010
TRACTION DRIVE	42.40	70.50	0.00	122.57	13,807	7,314	20,872
WHEELS	46.12	70.50	0.00	123.50	19,401	12,410	28,743
DRIVE CONTROLS	18.98	54.57	-5.24	107.19	2,105	4,267	5,572
CREW STATIONS	21.66	70.84	0.00	108.93	6,223	6,283	8,767
POWER SYSTEM	151.30	62.06	0.30	108.51	27,722	16,162	24,201
NAVIGATION	16.80	57.38	3.66	109.71	1,872	1,528	1,198
THERMAL PROTECTION	15.70	57.88	-3.64	104.88	1,684	1,416	2,569
MSFC ADDITIONS	19.00	74.97	0.56	110.06	1,541	2,235	1,823
SUBTOTAL	433.46	66.90	-0.09	110.88	122,691	146,249	196,212
SPACE SUPPORT EQUIPMENT	26.80	75.86	3.85	116.96	14,143	25,377	31,809
SSE THERMAL PROTECTION	0.60	75.86	3.85	116.96	0	0	0
TOTAL (INCLUDING SSE)	460.93	67.43	0.14	111.24	138,191	174,652	230,490

FIGURE 3

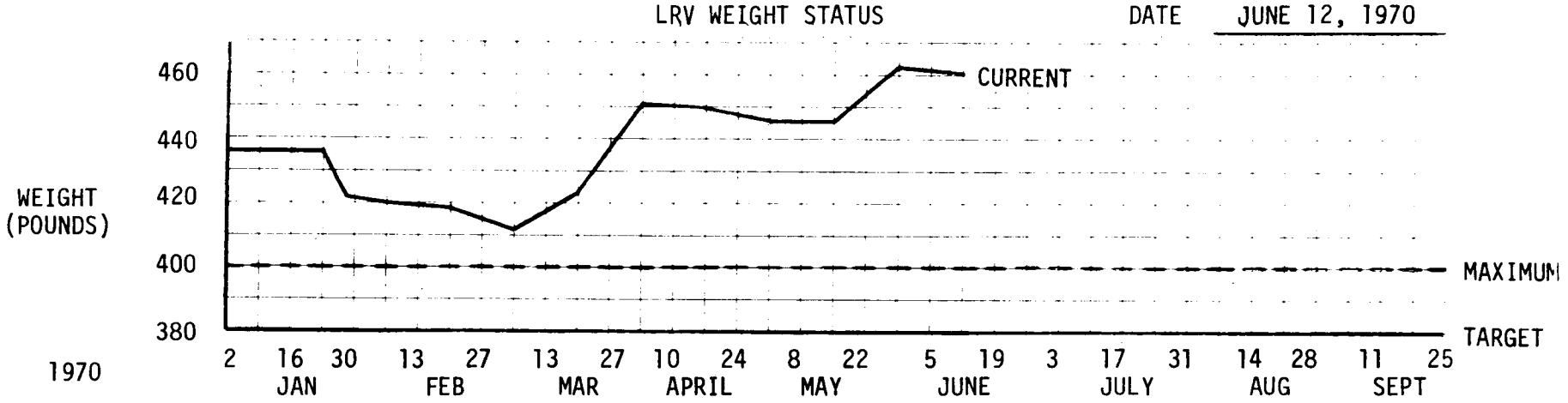
LRV MASS PROPERTIES

LRV DEPLOYED

JUNE 12, 1970

ITEM	TOTAL WEIGHT	CENTERS OF GRAVITY			MASS MOMENTS OF INERTIA		
		X Inches	Y Inches	Z Inches	I_x(lb-in^2)	I_y(lb-in^2)	I_z(lb-in^2)
CHASSIS	70.22	68.72	0.00	101.73	18,075	79,993	97,861
SUSPENSION	19.64	71.50	0.00	101.43	13,538	40,940	54,274
STEERING	9.40	71.50	0.00	101.37	1,188	13,118	14,304
TRACTION DRIVE	42.40	71.50	0.00	100.52	51,188	85,787	136,901
WHEELS	46.12	71.50	0.00	100.50	63,061	99,557	156,454
DRIVE CONTROLS	18.98	45.55	-5.24	106.92	2,123	7,960	9,246
CREW STATIONS	21.66	73.64	0.00	111.73	7,466	10,565	16,017
POWER SYSTEM	151.30	30.46	0.30	105.86	23,173	52,191	64,780
NAVIGATION	16.80	31.97	3.66	108.81	2,003	3,952	3,490
THERMAL PROTECTION	15.70	30.12	-3.64	105.92	1,665	2,904	4,075
SPACE SUPPORT EQUIPMENT	0.95	74.66	0.00	103.69	106	793	889
MSFC ADDITIONS	19.00	74.82	0.56	107.30	1,392	28,623	28,36
TOTAL	432.17	52.76	-0.09	104.31	190,175	600,439	757,452

FIGURE 4



LEVEL V SUBSYSTEM	RESPONSIBLE SUPERVISOR	TARGET WEIGHT (POUNDS)	CURRENT WEIGHT				PROPOSAL WEIGHT	LAST REPORT WEIGHT	COMMENT OR REASON FOR STATUS CHANGE
			WEIGHT	PERCENTAGE					
				EST	CALC	ACT			
CHASSIS	VERKAIK	62.0	72.5	4.3	95.7	-	49.8	69.4	WEIGHTS REVISED BASED ON RELEASED FLIGHT DRAWINGS
SUSPENSION	HARAWAY	19.0	19.6	-	100	-	25.6	19.6	
STEERING	HARAWAY	8.0	9.4	-	100	-	10.8	9.3	TIE ROD ASSEMBLY WEIGHT INCREASE
TRACTION DRIVE	HARAWAY	43.0	42.4	-	100	-	42.4	42.4	
WHEELS	HARAWAY	48.0	46.1	1.2	98.8	-	49.6	48.4	REDESIGNED INNER FRAME
DRIVE CONTROLS	HARAWAY	17.0	19.0	10.5	89.5	-	10.4	18.5	UPDATED WEIGHT CALCULATIONS
CREW STATIONS	VERKAIK	18.0	21.7	1.4	98.6	-	39.6	22.7	WEIGHTS REVISED BASED ON RELEASED FLIGHT DRAWINGS
BATTERIES	EKIS	110.0	118.0	100	-	-	118.0	118.0	
POWER SYSTEM	EKIS	16.0	33.3	49.8	50.2	-	15.4	33.3	
NAVIGATION	EKIS	16.0	16.8	1.8	98.2	-	20.0	16.8	
SPACE SUPPORT EQUIPMENT	MOORE	16.0	26.8	71.6	28.4	-	17.9	26.7	WEIGHTS REVISED BASED ON RELEASED FLIGHT DRAWINGS AND TEST HARDWARE SKETCHES
THERMAL PROTECTION	VERKAIK	7.0	16.3	95.7	4.3	-	-	18.9	REDUCED WEIGHT OF SPU FUSIBLE MASS
*MSFC-ADDED ITEMS	-	-	19.0	100	-	-	-	19.0	
TOTAL		380.0	460.9	42.2	57.8	-	399.5	463.0	

FIGURE 5

LRV WEIGHT STATUS (MSFC)

SUBSYSTEM	AS PER 6-12-70 REPORT	AS PER 7-15-70 REPORT	Δ	REASON FOR CHANGE
CHASSIS	72.5	81.5	9.0	–LCRU MOUNTS COUNTED AGAINST CHASSIS (3.0) –INCREASED STRUCTURAL WEIGHT (6.0)
SUSPENSION	19.6	19.64		
STEERING	9.4	9.40		
TRACTION DRIVE	42.4	42.40		
WHEELS	46.1	47.97	.9	THICKER TREAD STRIP REQUIRED
DRIVE CONTROLS	19.0	18.98		
CREW STATIONS	21.7	21.70	4.4	–INCREASED FENDER OVERLAP (3.0) –INCREASED HANDHOLD (.7) –SOLID SEAT BACK FOR PLSS SUPPORT (.5)
BATTERIES	118.0	116.0	–2.0	REDUCED WEIGHT BASED ON PROTOTYPE HARDWARE
POWER SYSTEM	33.3	38.83	5.5	–INCREASED CABLE GAUGE –INCREASED EMI SHIELDING –ADDED AUXILIARY OUTLET
NAVIGATION	16.8	16.84		
SPACE SUPPORT EQUIPMENT	26.8	41.77	15.0	MODIFIED DEPLOYMENT MECHANISM
THERMAL PROTECTION	16.3	20.6	4.3	–MATERIAL CHANGE IN THERMAL BLANKET –INCREASED NAV. POWER REQUIREMENTS
*MSFC-ADDED ITEMS	19.0	15.0	–4.0	–LCRU MOUNTS COUNTED AGAINST CHASSIS (3.0) –AUX. POWER CONNECTOR UNDER POWER SYS. (1.0)
CONTINGENCY	0	5.97	6.0	ADDED
TOTAL	460.9	500.0	39.1	

FIGURE 6

CANDIDATE LRV PROGRAM WEIGHT
REPORTING DEFINITIONS

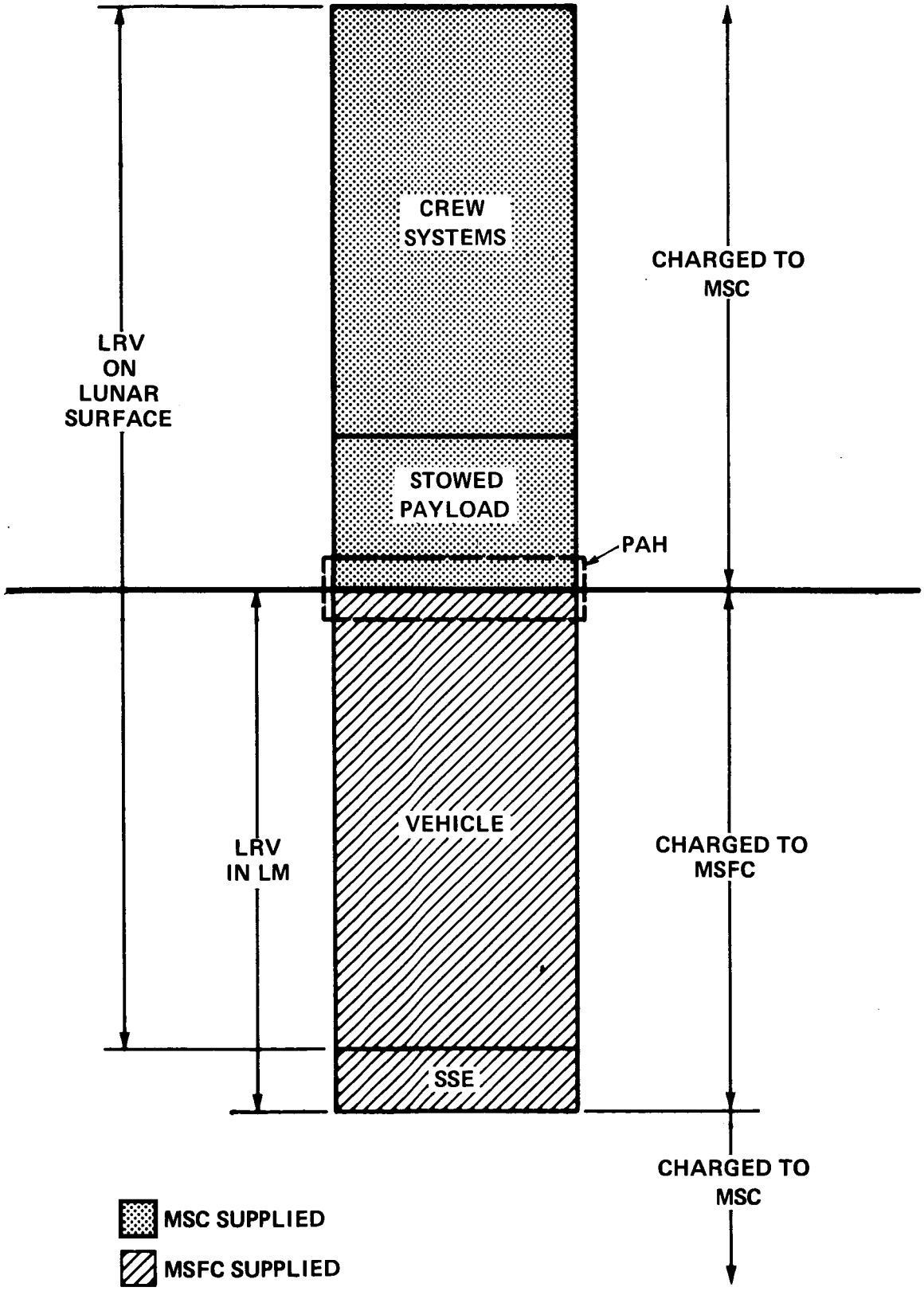
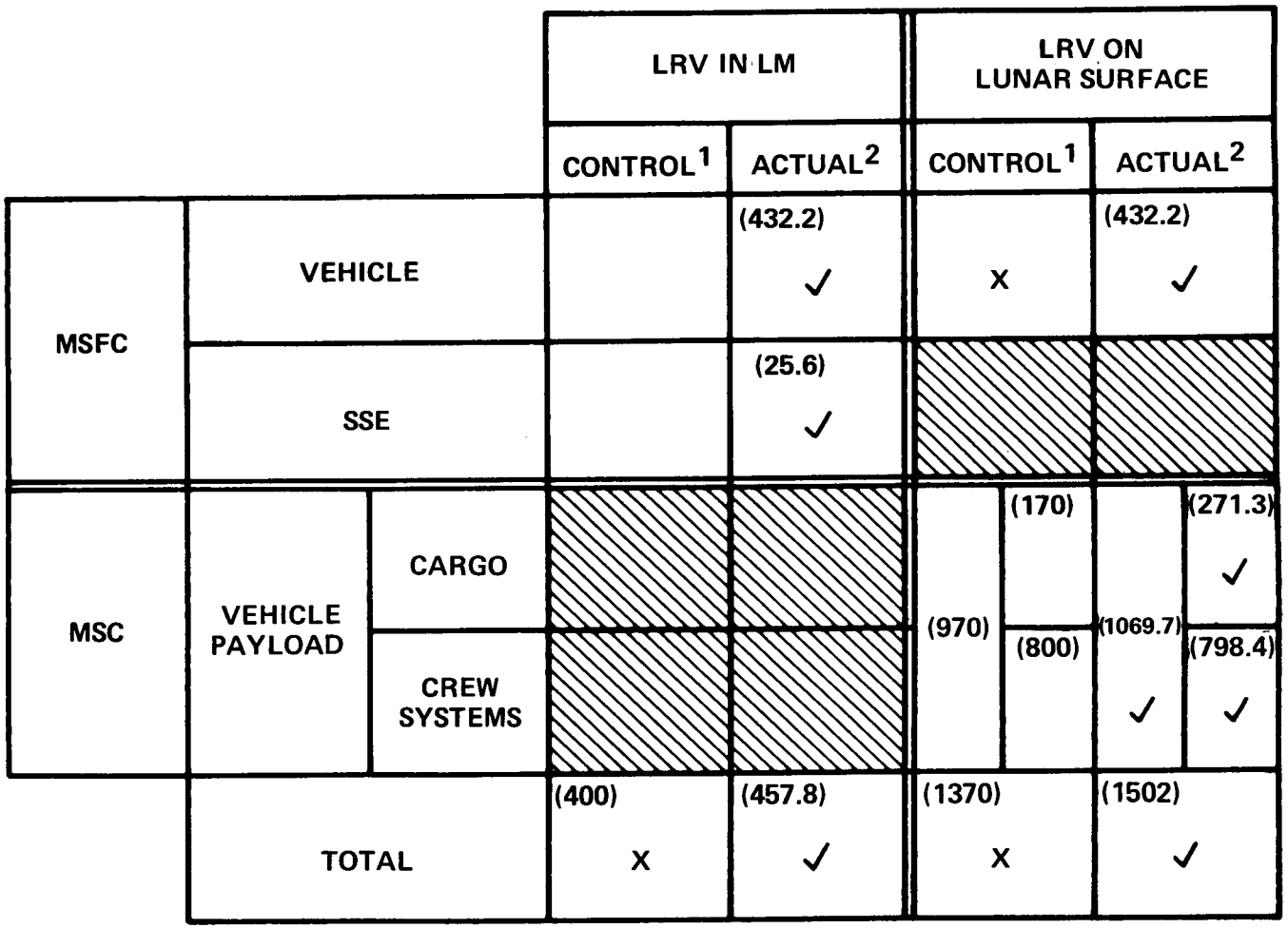


FIGURE 7

CANDIDATE REPORTING FORMAT



X PROGRAM CONTROL

✓ REPORTED TO MA MONTHLY

1. ( ) DERIVED FROM APOLLO PROGRAM SPEC.
2. ( ) DERIVED FROM 7-1-70 MSC REPORT.

FIGURE 8

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